

CFT₆ Bulk/Boundary AdS₅^Q Correspondence and Emergent Gravity

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We revisit a non-perturbation theory of quantum gravity in 1.5 order underlying an emergent gravitational pair of (4 $\bar{4}$)-brane with a renewed interest. In particular the formulation is governed by a geometric torsion \mathcal{H}_3 in second order with an on-shell NS form in first order. Interestingly the gravitational pair is sourced by a Kalb-Ramond two form CFT on a D_5 -brane in $d=10$ type IIB superstring theory. We show that a generic form theory containing a CFT sector in $d=6$ bulk may be described by a boundary AdS₅ with a quintessence Q. Analysis reveals that the bulk/boundary duality in emergent gravity can be a potential tool to explore the quintessential cosmology.

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Introduction: Holographic principle [1], underlying a correspondence between bulk and boundary dynamics, is believed to unfold some of the non-perturbation (NP) tools and their consequences to a perturbation world. In particular the correspondence between a five dimensional anti de Sitter (AdS₅) gravity in bulk and a four dimensional conformal field theory (CFT₄) at the boundary is a remarkable phenomenon [2–4]. The novel idea has lead to a NP-theory and has been perceived using a strong-weak coupling duality in superstring theory [5]. In fact the bulk/boundary duality has been explored extensively for diverse phenomena in the last two decades. The spontaneous symmetry breaking phenomenon at the event horizon of a black hole has turned out to be exciting [6, 7]. It is believed to lead to an unified description under the NP-quantum theory of gravity. Pioneering attempt to obtain the quantum theory of gravity using gauge theoretic tool(s) have also been explored [8, 9].

In the context Dirichlet (D) brane is known to be a NP-dynamical object in $d=10$ type II superstring theories [10]. A D_p -brane propagation describes a $(p+1)$ -dimensional hyper-surface. It can be sourced by a non-linear $U(1)$ boundary dynamics of an open string in presence of a constant Neveu-Schwarz (NS) two form background [11] and hence its dynamics is approximated by the Dirac-Born-Infeld (DBI) action. Mathematical difficulties donot allow an arbitrary NS form on a D_p -brane. Nevertheless, the NS form dynamics is known to incorporate a torsion in the string effective action underlying the string world-sheet conformal symmetry. Though certain aspect of a torsion in (super)string theory has been investigated in the past [12, 13], its connection to a D_p -brane has not been explored to its strength.

In the recent past author(s) in collaborations, have addressed the NS form gauge dynamics in an emergent scenario on a fat 4-brane [14–22] and subsequently underlying a CFT₆ on a fat 5-brane [23, 24]. In fact, a fat $(p+1)$ -brane is governed by a NS form dynamics in an emergent perturbation theory in first order. Investigation has revealed that the emergent phenomenon is described on a gravitational pair of $(p\bar{p})$ -brane for $p \leq 8$ and incor-

porates a dynamical NP-correction precisely described by a geometric torsion \mathcal{H}_3 in second order. Thus a NP-theory of quantum gravity has been shown to be governed by the \mathcal{H}_3 in 1.5 order for an on-shell NS form [25]. It may be viewed with the exchange of closed string(s) in between a D_p -brane and an anti D_p -brane in type II superstring theories. It has been shown that the emergent semi-classical geometries receive a NP-correction sourced by a lower dimensional D_p -brane underlying a geometric torsion theory. Recently an intrinsic aspect of NP-tool has been explored to generate mass for the gauge field and NS form in a perturbation gauge theory [26].

In the article we explore an important aspect of NP-tool leading to two equivalent dynamical description in terms of bulk CFT₆ and boundary AdS_5^Q underlying a fat 5-brane. Unlike to AdS₅/CFT₄ correspondence [2, 3], the CFT₆ in bulk/boundary AdS₅^Q underlies an emergent NS form theory in first order. The proposed correspondence is a generic feature between a NS form dynamics on a fat $(p+1)$ -brane and an emergent metric dynamics on a p -brane in a NP-formulation.

D_p-brane and NS form: We begin with a (bosonic) open string world-sheet dynamics in presence of the massless closed string backgrounds: metric $g_{\mu\nu}(X)$, Neveu-Schwarz (NS) two form $B_2^{(NS)}(X)$, and dilatonic scalar $\Phi(X)$. The non-linear sigma model action underlie an open string $X^\mu(\sigma, \tau)$ in the world-sheet bulk. For a constant Φ , the world-sheet action may be given by

$$S = -T \int d^2\sigma \left(\sqrt{-h} h^{ab} g_{\mu\nu} + \epsilon^{ab} \bar{F}_{\mu\nu}^{nl} \right) \partial_a X^\mu \partial_b X^\nu, \quad (1)$$

where $T = (2\pi\alpha')^{-1}$ is the fundamental string tension, h is the determinant of the world-sheet metric h_{ab} . The non-linear field strength $\bar{F}_{\mu\nu}^{nl} = (2\pi\alpha') F_{\mu\nu}^{nl}$ remains $U(1)$ gauge invariant in a combination of transformations for the gauge fields A_μ and $B_{\mu\nu}^{(NS)}$. Explicitly:

$$\bar{F}_{\mu\nu}^{nl} = B_{\mu\nu}^{(NS)} + \bar{F}_{\mu\nu}, \text{ where } F_{\mu\nu} = \nabla_\mu A_\nu - \nabla_\nu A_\mu. \quad (2)$$

The linear field strength $F_{\mu\nu}$ is uniform, which is indeed an electromagnetic field. However the modified $F_{\mu\nu}^{nl}$ turns out to be non-uniform in the bulk in presence of a NS

form. Under the $U(1)$ gauge transformation of forms, $\delta A_\mu = \nabla_\mu \epsilon$ and $\delta B_{\mu\nu}^{(NS)} = (\nabla_\mu \mathcal{E}_\nu - \nabla_\nu \mathcal{E}_\mu)$, the respective field strengths $F_{\mu\nu}$ and $H_{\mu\nu\lambda}^{(NS)} = 3\nabla_{[\mu} B_{\nu\lambda]}^{(NS)}$ remain invariant. They contribute to the string effective action, which is obtained using the conformally invariant world-sheet *i.e.* β -function(s) = 0.

For a constant NS form in the open string bulk, $H_{\mu\nu\lambda}^{(NS)} = 0$ in the string effective action. Then, the field strength $F_{\mu\nu}^{nl}$ turns out to be a constant. The second term in the bulk (1) is re-expressed as a boundary integral, which perceives the propagation of D_p -brane with $(25-p)$ Dirichlet conditions. The DBI action underlying a D_P -brane is given by

$$S_{\text{DBI}} = \frac{-1}{g_s (2\pi)^p (\alpha')^{(p+1)/2}} \int d^{p+1}x \sqrt{g_{\mu\nu} + \bar{F}_{\mu\nu}^{nl}}. \quad (3)$$

It shows that a D_p -brane is precisely governed by A_μ , while its global property is modified by a constant NS form. Since a global NS form cannot be gauge away, it modifies a point charge to a non-linear charge and hence $F_2 \rightarrow F_2^{nl}$. However the $U(1)$ gauge invariant $F_2^{nl} \rightarrow B_2^{(NS)}$ as F_2 can be gauged away.

Furthermore a D_p -brane is flat, *i.e.* defined with a constant metric $g_{\mu\nu}$, as the closed strings are tangential to its world-volume. A constant NS form modifies the constant $g_{\mu\nu}$ and leads to an open string metric $\tilde{G}_{\mu\nu} = (g_{\mu\nu} - B_\mu^{(NS)\lambda} B_{\lambda\nu}^{(NS)})$ on a D_p -brane [11]. Arguably the open string metric defines a nontrivial potential generated by a global mode of NS form on a D_p -brane. In the recent past, the metric potential is explored to obtain various near horizon black hole geometries [27–34].

D_4 -brane and KR form: Generically the DBI action can be re-expressed in terms of a higher ($p \geq 2$) form $U(1)$ gauge theory on a $D_{(p+2)}$ -brane. For simplicity $p=2$ has been explored in the recent past [14–24] to explain diverse phenomena underlying a semi-classical emergent theory of metric in a NP-formulation of quantum gravity on a gravitational pair.

Very recently the NP-formulation was further reviewed with a renewed interest to obtain a dynamical geometric torsion correction $\mathcal{F}_4 = (d\mathcal{H}_3 - \mathcal{H}_3 \wedge \mathcal{F}_1)$ in second order to an emergent metric [25]. An attempt has been made to obtain the M -theory in $d=11$ on a gravitational pair of $(M\bar{M})$ -brane from $d=12$ form theory underlying a fundamental gravitational 3-brane dynamics. The NP-tool has further been exploited to generate mass for the NS-form on a fat 3-brane [26]. It was argued that an axionic scalar dynamics $\mathcal{F}_1 = d\psi$ underlying a NP-correction is absorbed to generate a massive NS form in a perturbative vacuum. Interestingly ψ plays the role of a goldstone boson in perturbation theory. It transforms a flat D_4 -brane to a fat 4-brane.

In fact, the non-linear $U(1)$ gauge dynamics on a D_4 -brane has equivalently been realized with a linear $U(1)$

symmetry [11]. Interestingly the gauge theory may also be re-expressed with a Kalb-Ramond (KR) two form dynamics using the Poincare duality. Then, the non-linear gauge dynamics of a D_4 -brane, defined with a constant NS form and a local KR form, in presence of a background (open string) metric may be given by

$$S = \frac{-1}{(8\pi^3 g_s) \alpha'^{3/2}} \int d^5x \sqrt{-\tilde{G}^{(NS)}} H_{\mu\nu\lambda} H^{\mu\nu\lambda}, \quad (4)$$

where $H_{\mu\nu\lambda} = 3\nabla_{[\mu} B_{\nu\lambda]}^{(KR)}$ is sourced by a string charge.

Fat 4-brane and NS form: In particular a KR quantum, in the world-volume gauge theory on a D_4 -brane, has been argued to vacuum create a stringy pair across an event horizon of a background black hole underlying the fundamental principle of Schwinger pair production mechanism [35]. The NP-tool has further been explored to explain the Hawking radiation phenomenon [36] at the event horizon of a black hole. The mechanism has been explored for an open string pair production by an electromagnetic field [37] and for a vacuum pair of $(D\bar{D})_9$ at the cosmological horizon [38].

In the context the absorption of KR quanta leading to an emergent stringy pair has been realized geometrically, when $H_{\mu\nu\lambda}$ is exploited as a torsion connection [14–16]. A torsion modifies the covariant derivative operator ∇_μ on a D_4 -brane to \mathcal{D}_μ on an emergent fat 4-brane. The modified covariant derivative operation on a NS form turns out to be significant and is given by

$$\mathcal{D}_\lambda B_{\mu\nu}^{(NS)} = \frac{1}{2} \left(H_{\lambda\mu}{}^\rho B_{\nu\rho}^{(NS)} + H_{\lambda\nu}{}^\rho B_{\rho\mu}^{(NS)} \right), \quad (5)$$

where $\nabla_\mu B_{\mu\nu}^{(NS)} = 0$ as the NS form is covariantly constant on a D_4 -brane. An emergent fat brane evolves with a dynamical NS field and is obtained at the expense of the KR field dynamics on a D_4 -brane. It has been shown that the emergent dynamical NS form defines a geometric torsion: $\mathcal{H}_{\mu\nu\lambda} = 3\mathcal{D}_{[\mu} B_{\nu\lambda]}^{(NS)}$. Thus a constant NS form on a D_4 -brane has lead to a nontrivial \mathcal{H}_3 on an emergent fat 4-brane. It may well be understood via a coupling of a closed string to a D_4 -brane. It shows that a fat brane takes account for the quantum gravity underlying a NP-formulation. The NS form perturbation theory on a fat 4-brane may explicitly be viewed in terms of the KR form gauge theory on a D_4 -brane. It is given by

$$\mathcal{H}_{\mu\nu\lambda} = H_{\mu\nu\rho} B_\lambda^{(NS)\rho} + H_{\mu\nu\alpha} B_\rho^{(NS)\alpha} B_\lambda^{(NS)\rho} + \dots \quad (6)$$

A constant NS form turns out to be a perturbation parameter in the series expansion. Under an iterative correction: $H_3 \rightarrow \mathcal{H}_3$, the perturbation series (6) in $B_2^{(NS)}$ may equivalently be described as a NP-theory of a geometric torsion. The geometric torsion \mathcal{H}_3 retains the $U(1)$ gauge invariance under NS form transformation in an emergent perturbation theory defined with a modified covariant derivative \mathcal{D}_μ . However, the gauge invariance in a perturbation series (6) is apparently broken. Nevertheless, the gauge invariance has explicitly been restored

in the NS form theory [14, 19] in presence of a symmetric fluctuation: $f_{\mu\nu} = \mathcal{H}_{\mu\alpha\beta} \mathcal{H}^{\alpha\beta}{}_{\nu}$, where $\mathcal{H}_3 = (2\pi\alpha') \mathcal{H}_3$. It has lead to a dynamical (emergent) metric:

$$G_{\mu\nu} = \left(g_{\mu\nu} - B_{\mu}^{(NS)\lambda} B_{\lambda\nu}^{(NS)} + \bar{\mathcal{H}}_{\mu\lambda\rho} \mathcal{H}^{\lambda\rho}{}_{\nu} \right). \quad (7)$$

The local degrees of the metric on an emergent 3-brane is sourced by a dynamical NS form on a fat 4-brane in first order. Thus the emergent $(3\bar{3})$ -brane is identified as a gravitational pair. It ensures a fact that GTR emerges via a NP-tool in one higher dimension, *i.e.* in $d=5$. A geometric torsion in eq(7) incorporates an intrinsic angular momentum and naturally governs the Kerr family of black holes as a vacuum geometry [17, 18].

Gravitational pair and Higher-essence: The $U(1)$ gauge invariant \mathcal{H}_3 on a fat $(p+1)$ -brane leads to an emergent metric dynamics on a p -brane within a pair. The fact may be viewed as a generalization of the open string metric on a D_p -brane [11]. At a first sight, the emergent gravitational 4-brane (metric) dynamics sourced by $f_{\mu\nu}$ imposes 15-conditions on a NS form on a fat 5-brane. However they ensure an on-shell NS form, *i.e.* $\mathcal{D}^\lambda \mathcal{H}_{\lambda\mu\nu} = 0$, in 1.5 order and hence describes a propagating \mathcal{H}_3 in a NP-theory [25]. Thus an emergent two form curvature $\mathcal{K}_{\mu\nu} = \mathcal{D}^\lambda \mathcal{H}_{\lambda\mu\nu}$ becomes trivial which results in a four form \mathcal{F}_4 correction in second order.

A priori the KR form $U(1)$ gauge theory in $d=6$ may be identified as the bulk. A fat 5-brane dynamics has been realized as an emergent metric dynamics on a vacuum created pair of (44) -brane underlying a NP-formulation. Thus an emergent (44) -brane has been identified as a gravitational pair. A gravitational 4-brane is governed by the metric dynamics in $d=5$ and hence describes the Riemannian geometry. However the presence of a gravitational $\bar{4}$ -brane within a pair ensures a higher-essence (or hidden-essence or higher-dimensional) scalar (HS) to a 4-brane. Alternately, the HS may be identified with an extra dimension transverse to a gravitational 4-brane as the $\bar{4}$ -brane is hidden across an event horizon [23, 24].

CFT₆ Bulk/Boundary AdS₅^Q: In the context the perspectives of CFT, underlying a KR form $U(1)$ gauge theory, on a D_5 -brane may play an important role. A traceless energy-momentum tensor for the KR form ensures the conformal symmetry in the classical theory. The conformal anomaly can be set to vanish in a quantum field theory (QFT). This in turn describes a CFT for a KR form in $d=6$. It has been shown that the gauge theoretic vacuum may equivalently be described by a massless NS form in an emergent $d=6$ perturbation theory on a fat 5-brane [23]. A pair-symmetric emergent curvature tensor of order four has been shown to be sourced by a NS form with 6 local degrees in first order. They underlie an emergent NP-theory in $d=5$ on a fat 4-brane. The NP-correction $\hat{\mathcal{F}}_4 = (d\hat{\mathcal{H}}_3 - \hat{\mathcal{H}}_3 \wedge \hat{F}_1)$ in $d=6$ incorporates four local degrees. A plausible $\hat{F}_5 = d\hat{B}_4$ is Poincare dual to $\hat{F}_1 = d\hat{\psi}$ and possesses one local degree [25]. Thus a

B_p form theory in $d=6$ is described by 11-local degrees of freedom underlying $p = (2, 3, 4)$, which are respectively Poincare dual to the p' -forms for $p' = (2, 1, 0)$. Generically a form theory in $d=6$ may be given by

$$S = -\frac{1}{12\hat{\kappa}^4} \int_{bulk} d^6x \sqrt{-\hat{g}} \left(\hat{\mathcal{H}}_3^2 - \frac{\hat{\kappa}^2}{4} \hat{\mathcal{F}}_4^2 - \frac{1}{20} \hat{F}_5^2 \right), \quad (8)$$

where $\hat{\kappa} = \sqrt{2\pi\alpha'}$. The NP-correspondence between bulk CFT sector and boundary gravity (BG) in $d=5$ may be invoked in addition to a dimensional reduction on S^1 for the remaining curvature sector described by $\hat{\mathcal{F}}_4$ and \hat{F}_5 . The emergent gravity in $d=5$ has been obtained on a gravitational 4-brane within a pair of $(4\bar{4})$ -brane [23].

The curvatures $(\hat{\mathcal{H}}_3, \hat{\mathcal{F}}_4, \hat{F}_5)$ in the form theory correspond respectively to $(\mathcal{R}, d\phi_{HS})$, $(\mathcal{F}_4, \mathcal{F}_3)$ and (Λ, F_4) in $d=5$ emergent gravity. A constant five form in the boundary gravity theory signifies a cosmological $\Lambda = b(\mathcal{E}^{\mu\nu\lambda\rho\sigma} F_{\mu\nu\lambda\rho\sigma}) = (-120)b^2$ and hence describes an anti-de Sitter (AdS) geometry.

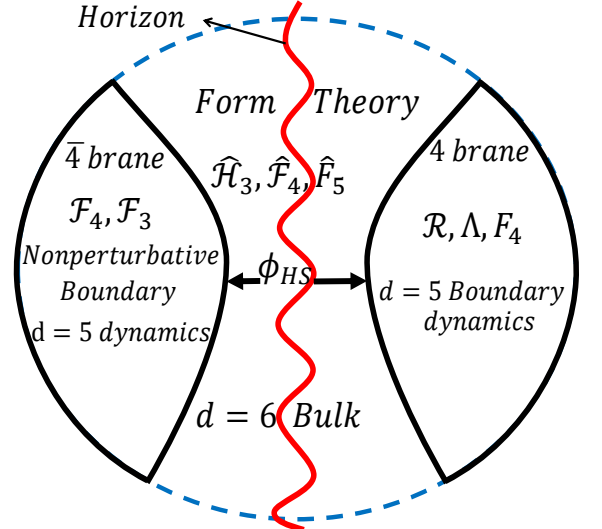


FIG. 1: Schematic diagram for CFT₆ bulk/boundary AdS₅^Q correspondence in NP-theory of quantum gravity. The NS form in bulk CFT₆ sector corresponds to the AdS₅ boundary on an emergent gravitational 4-brane and the NP-boundary dynamics on $\bar{4}$ -brane across a horizon. The 4-brane and $\bar{4}$ -brane may describe the quintessence cosmology and the nuclear interactions respectively. A dynamical HS inbetween the emergent pair presumably reveals a “gravito-nuclear” phase.

In a NP-decoupling limit, the weakly coupled 4-brane decouples from the strongly coupled $\bar{4}$ -brane. It is schematically shown in FIG-1. In the limit the HS dynamics, \mathcal{F}_4 and \mathcal{F}_3 on $\bar{4}$ -brane decouple. Then the boundary theory, with a coupling $\kappa = \sqrt{2\pi\alpha'}$, governs a gravitational 4-brane and is given by

$$S = \frac{1}{\kappa^3} \int_{BG} d^5x \sqrt{-g} \left(\mathcal{R} - \Lambda - \frac{1}{48} F_4^2 \right). \quad (9)$$

The 4-form signifies the presence of an interacting axionic scalar field in a semi-classical theory of gravity. The

non-canonical potential function for the axionic field is generated by the gravitational interaction. Interestingly the axionic field may be identified with a quintessence scalar dynamics in $d=5$ and is hidden to the GTR on an emergent 3-brane within a pair of (33)-brane.

Furthermore the semi-classical theory is governed by 6-local degrees. The difference of 5-local degrees, between the bulk and boundary theories, govern the decoupled NP-dynamics on an anti 4-brane. The momentum conservation at a pair production vertex ensures that the gravitational 4-brane and the NP-dynamics on an anti 4-brane moves away from each other along a generalized coordinate ϕ_{HS} across a horizon.

Apparently the emergent scenario implies a repulsive force hidden between a brane-universe and an anti-brane. Generically the HS field dynamics leading to a repulsive force may intuitively be realized with the coulomb force law between the same Ramond-Ramond (RR) charges from the perspective of an emergent gravitational 4-brane. In particular a vacuum pair generates an equal and opposite charge on a brane and an anti-brane across a horizon. Arguably a conserved mass, defined with a squared charge, changes its sign under a flip of light-cone at the horizon. It generates a repulsive force between a mass-pair [23, 38].

Hidden-essence in dual Riemann tensor: The $d=5$ semi-classical gravity, underlying a boundary theory, may be re-expressed in terms of left (L) and right (R) duals of the Riemann tensor [25]. The Q -essence coupling is absorbed within the duals and they are:

$$\begin{aligned} \mathcal{R}_{\mu\nu\lambda\rho}^{(L)} &= (2\pi\alpha') (F_{\mu\nu\alpha\beta} \mathcal{R}^{\alpha\beta}_{\lambda\rho}) \\ \text{and } \mathcal{R}_{\mu\nu\lambda\rho}^{(R)} &= (2\pi\alpha') (\mathcal{R}_{\mu\nu}^{\alpha\beta} F_{\alpha\beta\lambda\rho}) . \end{aligned} \quad (10)$$

The Riemann duals are checked for their irreducibility. A priori the dual(s) Ricci tensor of order two and a Ricci scalar are given by

$$\begin{aligned} \mathcal{R}_{\lambda\mu}^{(L)} &= \kappa^2 (F_{\lambda\rho}^{\alpha\beta} \mathcal{R}_{\alpha\beta\mu}^{\rho}) = \mathcal{R}_{\mu\lambda}^{(R)} = 0 \\ \mathcal{R}^{(L)} &= \mathcal{R}^{(R)} = \kappa^2 (\mathcal{R}_{\mu\nu\lambda\rho} F^{\mu\nu\lambda\rho}) = 0 . \end{aligned} \quad (11)$$

The cyclicity property of the Riemann tensor ensures the irreducibility of $\mathcal{R}_{\mu\nu\lambda\rho}^{(L)}$ and $\mathcal{R}_{\mu\nu\lambda\rho}^{(R)}$. The semi-classical theory of gravity (9) may be re-expressed in terms of the dual(s) of Riemann tensor and is given by

$$S = \frac{1}{\kappa^3} \int_{BG} \sqrt{-g} (\mathcal{R}_{\mu\nu\lambda\rho}^{(L)} R^{\mu\nu\lambda\rho}_{(L)} + \mathcal{R}_{\mu\nu\lambda\rho}^{(R)} R^{\mu\nu\lambda\rho}_{(R)} - \Lambda) \quad (12)$$

Remarkably the geometric duals hide an intrinsic coupling of $F_4 = *d\psi$ with the Riemann tensor. The coupling ensures an additional axionic scalar ψ dynamics in a metric tensor theory underlying the Riemannian geometry in $d=5$. The dynamical ψ -correction may be interpreted as a quintessence, which turns out to be a hidden

correction to the GTR. Quintessence is known as a potential candidate to describe the dark energy in universe and hence the semi-classical theory of gravity (12) may play a vital role to explore the dark gravity [39]. Needless to mention that the boundary gravity dynamics in an emergent pair production scenario differs from the novel idea of Kaluza-Klein compactification due to the underlying CFT₆ bulk/boundary AdS₅^Q correspondence.

Nevertheless, the dynamical contribution of quintessence becomes significant in $d \geq 5$. Thus five space-time dimensions turn out to be the minimal to explore a (non-supersymmetric) NP-theory. Primarily the dynamical correspondence in $d=5$ is between a KR form in gauge theory and a NS form in superstring theory. Both of them are two forms and they are different due to their differences in connection. Further investigation reveals that a quintessence is described by an axionic scalar in $d=5$, while its role (sixth essence) in $d=6$ is described by a massless gauge field A_μ with four local degrees of freedom. A count for the local degrees of NS form, in an emergent perturbation theory, precisely matches with that of a NP-correction in $d=7$ as \mathcal{H}_3 is Poincare dual to \mathcal{F}_4 . Generically the number of local degrees in a NP-correction is greater than the local degrees in a perturbative emergent theory for $d \geq 8$. An emergent gravitational pair of (88)-brane describes a space-filling D_9 -brane in type IIB superstring theory on S^1 , which is equivalent to the type IIA superstring on S^1 . Thus a NP-dominance in a supersymmetric formulation would like to begin with a minimal $d=10$ underlying a gravitational pair (88)-brane. It is in agreement with the strongly coupled NP-regime realized with the CFT₄ boundary dynamics on a D_3 -brane underlying the AdS₅ bulk in $d=10$ superstring theory. With a subtlety for an extra eleventh (small) dimension within a pair of (99)-brane, the supersymmetric NP-formulation of emergent gravity presumably justifies the $d=11$ non-perturbation M -theory.

In the context the bulk/boundary correspondence in an emergent gravity may appear to be surprising when compared with the AdS₅/CFT₄ correspondence [2–4]. However the apparent puzzle may be resolved in an emergent gravity, where bulk and boundary theories are governed in a NP-formulation. A subtle comparison with the bulk-gravity/boundary-CFT duality may imply that a NS field or generically a p -form for $p \geq 2$ is likely to incorporate gravitational effect(s) in the boundary, as they are sourced by a string charge for $p=2$ and a higher dimensional extended charge for $p>2$. Intuitively the boundary dynamics in a form theory, underlying an emergent scenario of pair production, is governed by an induced metric underlying a symmetric $f_{\mu\nu}$. Arguably, $f_{\mu\nu}$ possesses a source in the metric background for the (super)string world-sheet. A closed string exchange between an emergent ($p\bar{p}$)-brane pair further ensures the metric dynamics underlying the CFT₆/AdS₅^Q correspondence.

In addition the dynamical aspect of a two form inspires to believe in higher form *fundamental* theory in $d=12$. It has been shown to describe an emergent M -theory within a pair of $(M\bar{M})$ -brane [25]. A dynamical NP-correction does not modify an emergent metric, rather it incorporates a torsion and hence turns out to be non-Riemannian. Thus the quintessence QFT becomes insignificant in the GTR, which is a classical theory in $d=4$.

Bulk/Boundary in higher dimensions: Generically a massless NS form quantum dynamics in $(p+1)$ -dimensions is completely described by a metric tensor in p -dimensional classical theory in presence of a HS-QFT. Furthermore the NP-theory of emergent gravity ensures a generic correspondence between a fat $(p+1)$ -brane in bulk and the boundary dynamics on a gravitational p -brane within a vacuum created pair of $(p\bar{p})$ -brane. Thus a fat $(p+1)$ -brane in a strong coupling bulk gauge theory is dual to a weakly coupled boundary gravitational p -brane. The generic nature of $(bulk)_{p+1}/(boundary)_p$ correspondence in a NP-theory of emergent gravity is remarkable. It may provide a clue to an unified description of all four fundamental forces in nature.

Interestingly the CFT_6/AdS_5^Q correspondence may be reviewed from the perspective of $d=12$ *fundamental* theory [25]. In principle a space filling fat 9-brane, in type IIB superstring theory, underlies a gravitational 8-brane within a vacuum created pair of $(8\bar{8})$ -brane. Similarly a space filling boundary gravitational 9-brane may urge for a fat M -brane in $d=11$ bulk and viceversa. Preliminary analysis reveals that $d=12$ (higher) form theory, *i.e.* a B_p form for all $p \geq 2$, can be a potential candidate for a *fundamental* bulk theory and the corresponding boundary dynamics may describe the M -theory in $d=11$. It provokes thought to believe that the higher form(s) theory with a self-dual 6-form may describe all five superstring vacua in $d=10$ in an emergent quantum gravity scenario on pairs of $(9\bar{9})$ -brane. The detailed discussion is beyond the scope of this article and is in progress.

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- [1] L. Susskind, J.Math.Phys., 6377 (1995)
 [2] J.M. Maldacena, Adv.Theor.Math.Phys.**2**, 231 (1998)

- [3] E. Witten, Adv.Theor.Math.Phys **2**, 253 (1998)
 [4] I.R. Klebanov and E. Witten, Nucl.Phys.B**556**, 89 (1999)
 [5] A. Sen, Int.J.Mod.Phys.**9** 3707, (1994)
 [6] S.A. Hartnoll, C.P. Herzog and G.T. Horowitz, JHEP **0812**, 015 (2008)
 [7] S. S. Gubser, Phys.Rev. **D78** (2008) 065034
 [8] F. Wilczek, Phys. Rev. Lett.**80**, 4851 (1998)
 [9] F. Wilczek, arXiv:1512.02094 [hep-ph] (2015)
 [10] J. Polchinski, Phys. Rev. Lett.**75**, 4724 (1995)
 [11] N. Seiberg and E. Witten, JHEP **09**, 032 (1999)
 [12] S. Candelas, G.T. Horowitz and A. Strominger, Nucl. Phys.**B258**, 46 (1985)
 [13] D.S. Freed, Comm.Math.Phys. **107**, 483 (1986)
 [14] A.K. Singh, K.P. Pandey, S. Singh and S. Kar, JHEP **05**, 033 (2013)
 [15] A.K. Singh, K.P. Pandey, S. Singh and S. Kar, Phys.Rev. **D88**,066001 (2013)
 [16] A.K. Singh, K.P. Pandey, S. Singh and S. Kar, Nucl. Phys.**B252-252** (2014) 241
 [17] S. Singh, K.P. Pandey, A.K. Singh and S. Kar, Nucl. Phys.**B879**, 216 (2014)
 [18] S. Singh, K.P. Pandey, A.K. Singh and S. Kar, Int. J. Mod. Phys. **A29**, 1450164 (2014)
 [19] K.P. Pandey, A.K. Singh, S. Singh, R. Kapoor and S. Kar, Eur.Phys.J. **C74** , 3173 (2014)
 [20] K.P. Pandey, A.K. Singh, S. Singh and S. Kar, Int. J. Mod. Phys. **A30**, 1550065 (2015)
 [21] K.P. Pandey, A.K. Singh, S. Singh and S. Kar, Int.J. Innovative Res. Sc. Engg. Tech.**5**, 09 (2016)
 [22] D. Singh and S. Kar, Int.J.Innovative Res. Sc. Engg. Tech.**4**, 08 (2016)
 [23] R. Kapoor, S. Kar and D. Singh, Int. J. Mod. Phys. **D24**, 1550015 (2015)
 [24] D. Singh, R. Kapoor, S. Kar, Springer.Proc.Phys.**174**, 507 (2016)
 [25] S. Kar, arXiv:1610.07347 [hep-th] (2016)
 [26] S. Kar and R. Nitish, arXiv:1611.04952 [hep-th] (2016)
 [27] G.W. Gibbons and K. Hashimoto, JHEP **09** (2000) 013
 [28] M. Mars, J.M.M. Senovilla and R. Vera, Phys. Rev. Lett.**86** (2001) 4219
 [29] G.W. Gibbons and A. Ishibashi, Class.& Quant. Grav.**21** (2004) 2919
 [30] S. Kar and S. Majumdar, Phys.Rev. **D74**, 066003 (2006)
 [31] S. Kar, Phys.Rev. **D74**, 126002 (2006)
 [32] S. Kar, JHEP **0610**, 052 (2006)
 [33] L-H. Liu, B. Wang and G-H. Yang, Phys.Rev. **D76** (2007) 064014
 [34] J. Zhang, Phys. Lett. **B668** (2008) 353
 [35] J. Schwinger, Phys.Rev. **82**, 664 (1951)
 [36] S.W. Hawking, Comm.Math.Phys. **43**, 199 (1975)
 [37] C. Bachas, M. Porrati, Phys. Lett. **B296**, 77 (1992)
 [38] M. Majumdar and A.-C. Davis, JHEP **03**, 056 (2002)
 [39] T. Padmanabhan, Res.Aston.Astrophys.**12**, 891 (2012)